SYNTOMASPIS DRUPARUM, THE APPLE-SEED CHALCID

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INTRODUCTION

Since the publication by Crosby (7 [1], p. 369) of his paper on the apple-seed chalcid (*Syntomaspis druparum* Boh.) this insect has attracted more and more attention among those associated with the apple industry, and numerous letters relating to it have been received at the Bureau of Entomology. The frequency and wide distribution of these inquiries and complaints seemed to warrant a rather detailed investigation of the insect, and the writer has spent portions of the past two seasons (1914 and 1915) in such an investigation. The biological work was done at the field laboratory for the investigation of deciduous-fruit insects of the Bureau of Entomology at North East, Pa., while the field observations have been conducted throughout the northern tier of States from Vermont to Michigan.

DESCRIPTION OF THE ADULT INSECT

The adult insect is somewhat wasplike in appearance, bright green, with coppery or bronzy metallic reflections, brownish yellow legs, and clear hyalin wings. The female (Pl. 37, A) is normally about 4 mm. in length and is provided with a slender ovipositor slightly longer than the body. The male (Pl. 37, B) is somewhat smaller than the female.

DISTRIBUTION IN THE UNITED STATES

The apple-seed chalcid apparently occurs throughout the northern tier of States, at least from Vermont to Michigan. It has not been found in Ohio or Indiana. At the time of the writer's visit to those States there was a very small crop of apples, and none especially suitable for the attack of the insect were found. But in the same season the chalcid was found in the seeds of a wild seedling at Benton Harbor, Mich. The writer has also found it as far south as Clearfield, Pa., and some years earlier what was almost undoubtedly the larva of this species was found in a crab apple (*Malus* sp.) at Vienna, Va. It is probably distributed throughout the eastern part of the country wherever small seedling apples (*Malus sylvestris*) are to be found.

HISTORICAL REVIEW

Crosby (7, p. 369; 9) has given a nearly complete résumé of the history of the apple-seed chalcid in Europe, where it has been well treated

[1] Reference is made by number to "Literature cited," p. 501.

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recently by Mokrzecki (4). His own papers record the only original observations on the species in America. The insect was first discovered by Prof. Crosby in July, 1906, at Ithaca, N. Y., when he found the seeds of crab apples to contain the partly grown larvæ. His first report of his discovery appeared in 1908 (6, p. 38), and the following year he published his full account (7, p. 369). In the latter paper he summarizes most of the previously published accounts of the species and records in detail his own observations in regard to life history, habits, distribution, and host fruits and gives descriptions of the stages. His 1912 paper (9) consists of further résumés of European literature.

From the wide distribution of the species it is evident that it must have been present though undiscovered in America for a long time, but any statement as to the time of its introduction can be nothing more than speculation. However, that there have been many opportunities for its introduction in the past and that it has been repeatedly introduced in fruit from Europe can not be doubted. It may even have been brought to America before its discovery in Europe, and its establishment here may have been effected at that early time; for it is a historical fact that in the early days of American history apples were imported and their seeds planted by the colonists. Much of the early spread of the apple to the West was due to the Indians, who planted in favorable spots the seeds from apples given them by the settlers. These trees, planted mostly along the trails to the West, would form easy avenues of distribution, and it is quite likely that they and their progeny have aided in the spread of the insect.

EFFECT UPON FRUIT

The only externally visible effect of infestation is caused by the oviposition puncture, which, after a few days, appears as a minute scar situated in a small, shallow dimple. From this scar to the seed extends a discolored line. Under ordinary circumstances of growth and infestation the fruit apparently is able to outgrow both of these manifestations of injury. But occasionally, especially when fruit is scarce or the insects very abundant, the gross injury due to repeated puncturing at nearly the same spot causes permanent and deep dimpling, together with corky, discolored streaks in the flesh. However, even in 1915, when suitable fruit was rather scarce, the season cold, and the chalcids abundant in the region of North East, Pa., such injury was the exception rather than the rule; and in 1914, when the converse of these conditions prevailed, no single case of severe distortion that could be attributed to this species was found. Distorted fruit is shown in Plate 38, A, B, C.

Frequently injury caused by other insects is attributed to the apple-seed chalcid because at the time the injury is noted this species is the only one present. As an example of this, the case of an orchard near Clearfield, Pa., may be cited. The bulk of the fruit in this

orchard in 1914 was very badly distorted, and specimens sent to various entomologists were pronounced to be the work of *Syntomaspis druparum* for the reason that larvæ of this species were found in the seed. The writer visited this orchard in October and examined large numbers of the fruits, but found the chalcid larvæ in comparatively few. Obviously the chalcid was not responsible for such extensive injury, especially in view of the fact that the fruit of wild seedlings almost within the boundaries of the orchard was heavily infested by the chalcid and showed no sign of distortion. Observation in the same orchard the following spring disclosed the fact that it was grossly infested by both species of apple red bugs (*Lygidea mendax* Reut. and *Heterocordylus malinus* Reut.), which had come from *Crataegus* sp. and wild crab in the surrounding woods. These were the insects responsible for the injury to the apples, and the chalcids were able to infest the seeds because of the stunting due to the red-bug injury. It should be stated, in justification of this mistaken determination, that both of the insects concerned are of comparatively recent discovery, and their work is familiar to but few entomologists.

When first infested, the seeds show the laceration caused by the ovipositor surrounded by a brownish area; but as they darken, the injured area heals and ultimately appears as a lighter area, a repeatedly punctured seed having a mottled appearance. At full growth infested seeds are less plump and more irregular than normal seeds. Infested and sound seeds are shown in Plate 39.

Crosby (7, p. 369) states that in the Lady apple the texture of the flesh is considerably injured. This has not been apparent to the writer, for on visiting an orchard containing trees of this variety, from which the owner had picked what he termed an "unusually fine crop," fully two-thirds of the apples examined were heavily infested by the chalcid; but it was impossible to tell whether an apple was infested without examining the seeds or making an almost microscopic examination of the skin for the minute oviposition scars. Special attention was paid to apples of commercial size and color, and a very large percentage was found infested. Moreover, fruit of this variety has been purchased on the Washington market 50 per cent of the seeds of which contained larvæ of the chalcid.

Horvath records failure in Budapest of apple seed to produce a good stand on account of infestation by the chalcid.

VARIETIES AND SPECIES OF FRUIT ATTACKED

The apple-seed chalcid has been found to infest a great variety of fruits. The original description (1, p. 361–362) was based on specimens reared from the seeds of *Sorbus scandica*. The species was redescribed by Thomson (2, p. 76) from seeds of *Sorbus* sp. Rodzianko (5, p. 593–602) reared it from *Sorbus aria*, *Pyrus baccata*, and *Malus sylvestris*. In

Europe it has been mentioned a number of times in connection with the apple, but frequently without any statement as to the nature of the fruit. Porchinsky (3) records the rearing of a species of Torymus from the seeds of wild pear (*Pyrus communis*), but gives no specific determination of the insect. It may have been *Syntomaspis druparum*, but not certainly so. Crosby (7, p. 369) lists the Lady apple, natural fruit, the wild crab (*Pyrus* [*Malus*] *coronaria*), and the following cultivated crab apples: *Pyrus* [*Malus*] *sibricia* var. *striata*, *Pyrus* [*Malus*] *floribunda*, *Pyrus* [*Malus*] *prunifoliae*, and *Pyrus* [*Malus*] *ioensis*. He also states that larvæ, apparently the same, were found in the seeds of *Sorbus latifolia*, but that the adults were not reared. In correspondence with the Bureau of Entomology Mr. M. L. Benn, of Coudersport, Pa., states that he has found infestation by the seed chalcid in Northern Spy, Baldwin, Fameuse, Wagener, Russet, Tolman Sweet, and two seedlings. Mr. G. McL. Stevens, of Orwell, Vt., reported it as attacking Lady apples at Orwell, Vt., and natural fruit at Peru, N. Y., while Mr. A. E. Stene reports it from Kingston, R. I., in the seeds of crab apple.

The writer's observations on the species began a number of years ago at Vienna, Va., where what was undoubtedly the larva of the seed chalcid was found in a seed of a crab apple.

Since the beginning of the work on the species, many varieties of apples have been examined under many conditions and in widely separated localities. At practically every point visited nearly every variety of natural fruit, except the largest, has been found to be more or less generally infested.

Among cultivated varieties the Lady apple only is apparently subject to very serious attack, this variety being frequently very heavily infested. The ordinary commercial varieties are never infested except in neglected and run-down orchards or when fruit is stunted by the overloading of trees or by the attack of some other insect or disease. The reason for the immunity of the ordinary apples of commerce from attack is purely mechanical, in that, at the time the chalcids are ovipositing, such fruit is so large that the ovipositor will not reach to the seeds. However, under the circumstances enumerated above, such varieties are occasionally more or less infested, though never very heavily so. Larvæ have been found by the writer in neglected orchards at North East, Pa., in the following varieties: French Russet, Northern Spy, and Baldwin. In a large orchard near Clearfield, Pa., which in 1914 was very badly infested by red bugs (*Lygidea mendax* Reut. and *Heterocordylus malinus* Reut.), and the fruit much distorted and stunted thereby, only Grimes Golden, Ben Davis, and Missouri of the many varieties examined were infested. Of these Grimes Golden showed about 25 per cent of the fruit infested, from one to four seeds in the infested apples containing larvæ of the chalcid. Of the two other varieties only one apple each was found to be infested.

Crab apples, both cultivated and wild, are very frequently infested, but invariably to a less extent than the small wild seedlings of the true apple, and it is evident that the latter is the natural host of the insect. On one occasion the opportunity offered to compare the infestation in these two classes of fruit where wild crabs and wild seedlings were found growing side by side. Only about 50 per cent of the crabs were infested, and rarely more than one seed to the fruit contained larvæ, while the infestation in the seedling apples was practically 100 per cent, uninfested seeds being scarce.

Although the fruit of the common mountain ash (*Sorbus americana*) has been repeatedly and extensively examined, the writer has never found any trace of infestation by this or any other chalcid.

Neither pears nor the fruit of *Crataegus* sp. exposed to the attack of the chalcid in cages were infested, although attempts at oviposition on the latter were repeatedly observed and many fruits were exposed to attack and later examined.

LIFE HISTORY OF THE CHALCID

The life-history data given below were obtained very largely by propagation of the apple-seed chalcid on wild seedling fruit at North East, Pa., and involved the examination of many hundreds of apples. The female insects were caged on fruit for one day in cages constructed of mica lamp chimneys and cheesecloth (Pl. 40, D).

EMERGENCE IN SPRING

The insects reared in 1914 were from a lot of apples that had been kept in Washington, D. C., during the previous winter and until about May 15, when they were shipped to North East, Pa. The earlier spring of Washington undoubtedly hastened somewhat the emergence of some of the earlier reared adults, for they began to emerge from the seeds on May 26, which was some time before the apples at North East were at the proper stage for oviposition. However, they did not begin to appear in numbers until after the middle of June, the heaviest emergence occurring during the week of June 22–29 and the last on July 5. The adults reared in 1915 were from apples that passed the winter in an unprotected wire cage at North East. The first to emerge appeared on June 16 and the last on July 16, with the heaviest emergence, as in 1914, during about the last week of June.

There appears to be very little, if any, difference in the time of emergence of the sexes. In the more normal emergence of 1915 a few males appeared before any females, and the few belated individuals that emerged after the first few days of July were all females. But during every other day of the emergence season some individuals of each sex appeared.

RELATIVE ABUNDANCE OF SEXES

The rearings during 1914 consisted of 254 females and 85 males, 74.9 and 25.1 per cent, respectively. In 1915, 316 females and 100 males were reared, 75.9 and 24.1 per cent, respectively. These figures show a ratio of about 3 females to each male.

OVIPOSITION

AGE AT BEGINNING.—The female chalcids become mature and able to deposit eggs within a very short time after emergence, for they have been repeatedly observed in the act of oviposition within two days after issuing from the seed.

AGE OF FRUIT.—At the time of the heaviest emergence of the chalcids apples have grown, depending on the variety, to a diameter of from a half inch to somewhat over an inch. The seeds have attained nearly full growth, but have not begun to harden. Most of the space within the seed is occupied by a jelly-like mass, with the small embryo at one end. Between this and the outer seed coat is a rather thick mucilaginous layer.

METHOD AND TIME REQUIRED.—In ovipositing, the female chalcid first feels carefully over the surface of the apple with her antennæ; then, when she has located a place to her liking, she raises the abdomen, at the same time releasing the ovipositor from its sheath and lowering it until its tip is against the surface of the apple directly beneath the posterior end of the thorax. The abdomen is now perpendicular to its normal axis. With pressure accompanied by a slow swinging of the abdomen from side to side the ovipositor is forced slowly into the apple until inserted to its full length. At the end of this time the abdomen has resumed nearly its normal position except that the hypopygidium is directed downward with the ovipositor, making a triangular projection below the abdomen. Now the ovipositor is several times partially withdrawn and thrust back until the insect is apparently satisfied that it has been properly inserted, when she remains perfectly quiet for a considerable period, during which the egg is deposited. When this is finished the ovipositor is withdrawn and swung back into its sheath. The whole process occupies, on the average, somewhat in excess of five minutes. Living chalcids in various phases of the act of oviposition are shown in Plate 40, B, C, while in A one is shown attempting oviposition in the fruit of *Crataegus* sp.

POINT OF ATTACK.—When oviposition first begins, most of the punctures are made around the middle of the apple, but later in the season the attack is shifted nearer to the calyx end. This is apparently made necessary by the fact that the growth of the apples makes it impossible for the ovipositor to reach the seed from the side. Figure 1 shows the position of punctures in fruit and seed.

RELATION BETWEEN PUNCTURES MADE AND EGGS DEPOSITED.—That the instinct of the ovipositing female in locating the seed is not so strong and unerring as might at first be supposed, when the frequent very high percentage of infestation of the seeds is considered, is indicated by the number of punctures made in the seed compared with the number showing on the surface of the apple. The puncture is much more conspicuous on the white seed than on the skin of the apple; yet one fruit that had been punctured 36 times had only five punctures on its seeds. It is unlikely that each puncture made represents an egg deposited, but rather that many punctures represent unsuccessful attempts at finding seed. This is borne out by the observations on ovipositing females, which frequently inserted their ovipositors repeatedly at almost the same point before ultimately going through all the phases of the act of oviposition. It is not even probable that every puncture in the seed represents the deposition of an egg. No definite assertion on this point can be made, since the eggs are rather difficult to find.

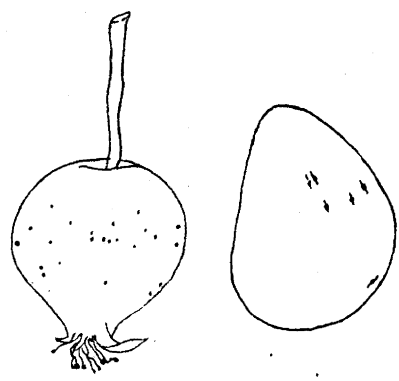

FIG. 1.—*Syntomaspis druparum:* Apple, natural size, and seed, enlarged, showing oviposition punctures. (Original.)

PLACE OF DEPOSITION OF EGG.—Apparently it is the aim of the insect to place its egg in the central gelatinous mass of the seed, and from the position of many of the punctures it is impossible that through them the ovipositor could have reached this body. Many punctures are on the side of the seed, in such position that the ovipositor must have been nearly tangent to the surface of the seed.

Sometimes eggs are deposited in the mucilaginous layer next to the seed coat, but the resulting larvæ apparently never mature, for many dead larvæ of the first instar have been found in this situation, and living larvæ found there have always been in the first instar and far behind, in growth, the larvæ of the same age in the more favorable jelly-like body.

OVIPOSITION PERIOD.—The longest period during which any of the caged females were ovipositing in 1914 was from June 25 to July 21, a period of 26 days, two insects in the same cage having died on the same date. During this time 48 apples were exposed, and all were more or less infested. Others lived for periods ranging from 3 to 24 days, the quicker deaths being due apparently to the sun striking the cages.

EGG

DESCRIPTION.—The egg (fig. 2) is elongate oval, roundly pointed at the caudal end, and prolonged at the cephalic end into a slender, twisted pedicle about one-fourth the diameter and nearly as long as the body

of the egg. Exclusive of this appendage, the egg is about 0.55 mm. in length by about a fourth as thick in the middle. It is yellowish white and without sculpture. Within two days after oviposition the embryo can be seen to have drawn away from the poles, and in some the cephalic constriction can be seen.

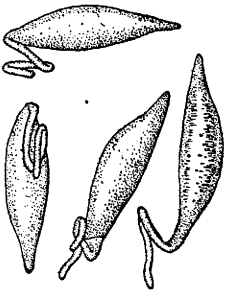

FIG. 2.—*Syntomaspis druparum:* Eggs. Highly magnified. (Original.)

INCUBATION PERIOD.—In 1914 the eggs began to hatch on the sixth day after deposition, and by the eighth day all had hatched. In 1915 hatching commenced on the seventh day and continued until the tenth day.

LARVA

NUMBER AND DESCRIPTION OF INSTARS.—The newly hatched larva (fig. 3) is about 0.4 mm. in length by about a fourth as thick at the thickest point, which is at the junction of the thoracic and abdominal segments. From this point it tapers in both directions, but is much smaller at the caudal end. The body, including the head, consists of 14 segments; the 3 thoracic segments are about equal in length, and the abdominal segments gradually decrease in length toward the caudal end. The head is nearly hemispherical and rather heavily chitinized. The mouth opening is nearly circular and surrounded by a raised rim. Owing to the minute size and delicacy of the mouth parts, except the strong mandibles, it is difficult to determine definitely their exact relation to each other, but they appear to be about as in the illustration (fig. 4). The mandibles are long, strongly curved, and dark colored. They cross in the middle of the mouth opening. The head is from 0.108 to 0.123 mm. in breadth and the mandibles 0.021 mm. in length. At full growth the larva of the first instar is slightly less than 1 mm. in length.

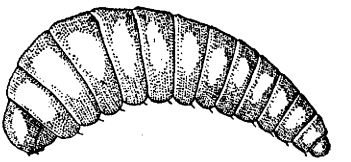

FIG. 3.—*Syntomaspis druparum:* Newly hatched larva. Highly magnified. (Original.)

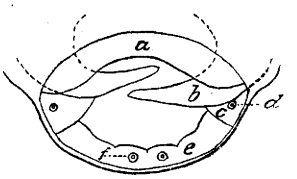

FIG. 4.—*Syntomaspis druparum:* Mouth parts of larva of first instar. *a*, Labrum; *b*, mandible; *c*, maxilla; *d*, maxillary palpus; *e*, labium; *f*, labial palpus. Highly magnified. (Original.)

The larva of the second instar is very similar in general appearance to that of the first instar, having the same tapering form though being somewhat stouter. It can, however, be easily distinguished by the weaker chitinization of the oral region and the change in the form of the mandibles, which at this molt assume a form more similar to those of the full-grown larva. The brown color of the mandibles is confined to their tips, and they are very stout at the base and much less strongly curved (fig. 5, *a*). The head in this instar is from 0.184 to 0.215 mm. broad,

and the mandibles from 0.036 to 0.039 mm. long. At full growth the second instar is about 1.5 mm. long.

With each succeeding molt the larva becomes gradually stouter and less tapering behind until at full growth it is more than a third as thick as long, with the caudal end but little more tapering than the head end, and the head becomes relatively smaller and more retracted within the thorax. With each molt the head and mandibles increase markedly in size, and the latter change somewhat in form. These changes in measurements and form constitute the only real differentiating characters until in the last instar the spiracles become open and visible.

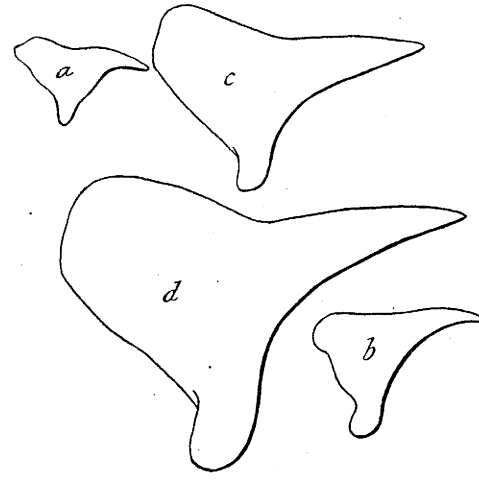

FIG. 5.—*Syntomaspis druparum:* Mandibles of larvæ of various instars. *a*, Second; *b*, third; *c*, fourth; *d*, fifth. Highly magnified. (Original.)

The head of the third-instar larva varies in breadth from 0.277 to 0.308 mm. and the length of the mandibles from 0.050 to 0.057 mm. The latter (fig. 5, *b*) are curved toward the apex. In the fourth instar the head is from 0.415 to 0.461 mm. broad and the mandibles (fig. 5, *c*) 0.079 to 0.086 mm. long and nearly straight at the apex.

The full-grown or fifth-instar larva (fig. 6) is of the typical chalcid form, rather spindle-shaped but somewhat curved toward the ventral side, with the head short and flattened and partially retracted within the first thoracic segment. The mesothoracic and metathoracic segments and the first seven segments of the abdomen bears each a pair of minute spiracles. Fully fed larvæ are mostly from 4.5 to 5 mm. long, but a few, which develop in small seeds, are much smaller, the smallest measured being 3 mm. in length. The head is from 0.554 to 0.6 mm. broad and the mandible (fig. 5, *d*), the blade of which is rather slender and nearly straight, is from 0.111 to 0.129 mm. long. The arrangement of the mouth parts is shown in figure 7.

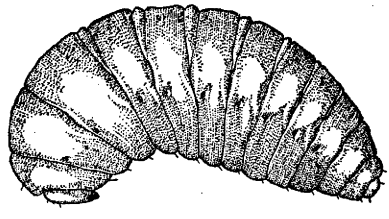

FIG. 6.—*Syntomaspis druparum:* Full-grown larva. Much enlarged. (Original.)

PLACE OF FEEDING.—The earlier feeding of the larva is done in the gelatinous portion of the developing seed. In the meantime the embryo is developing and the gelatinous body is being absorbed. Before the

latter entirely disappears the larva begins to feed on the cotyledons, eating out a pit on one edge or one side and ultimately devouring the last traces of the embryo.

DURATION OF INSTARS AND FEEDING PERIOD.—The two seasons during which observations on the life history of the apple-seed chalcid were made were quite different, and the development of the larvæ was consequently quite different in point of time required. The summer of 1915 was unusually cold, and the larvæ required about a week longer to complete their development than those of 1914.

The observations of 1914 were complicated and rendered somewhat difficult of interpretation because of an unexpected infestation from natural sources. The presence of the species in the locality was not discovered until too late to escape the infestation from that source. However, the natural infestation was, as a rule, either considerably earlier or considerably later than that in the cages, and some information of value can be secured from the data obtained.

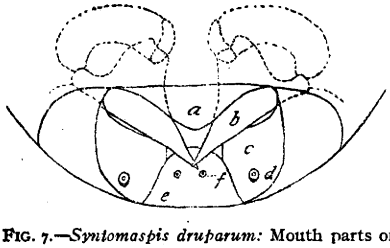

FIG. 7.—*Syntomaspis druparum:* Mouth parts of full-grown larva. *a*, Labrum; *b*, mandible; *c*, maxilla; *d*, maxillary palpus; *e*, labium; *f*, labial palpus. Highly magnified. (Original.)

In 1915 these difficulties were eliminated by the expedient of bagging all fruit to be used in the work both before and after it was exposed to the attack of the insects in the cages.

In 1914 the first individual of each instar was found about four days after the first of the immediately preceding instar, all transformations from one instar to the next taking place within a period of about a week. In about 45 days from oviposition practically all the larvæ had finished feeding. Table I gives the data on the development of the seed chalcid during 1914. From this table are excluded all individuals the presence of which was obviously due to natural infestation.

TABLE I.—*Development of Syntomaspis druparum at North East, Pa., in 1914*

Period from infestation to examination.	Date of infestation.	Date of examination.	Stages of insect found.					
			Eggs.	First larval.	Second larval.	Third larval.	Fourth larval.	Fifth larval.
Days.								
3–4	June 20–21	June 24	6					
4–5	July 3–4	July 8	3					
5–6	June 18–19	June 24	4					
6	June 25	July 1	17		2			
	July 2	July 8	3		3			
	July 9	July 15	2		4			
7	July 1	July 1	1		3			
8	June 23	...do			6			
	July 7	July 15			12			
8–9	June 29–30	July 8			3			
9	July 6	July 15			3			
	July 7	July 16			4			

TABLE I.—*Development of Syntomapsis druparum at North East, Pa., in 1914*—Contd.

Period from infestation to examination.	Date of infestation.	Date of examination.	Stages of insect found.					
			Eggs.	First larval.	Second larval.	Third larval.	Fourth larval.	Fifth larval.
Days.								
8–10	July 12–14	July 22		1				
10	July 6	July 16		1				
10–11	June 18–19	June 29		17				
	June 27–28	July 8		8				
11	July 5	July 16		2	4			
12	June 26	July 8		8				
12–13	July 3–4	July 16		1	3			
13	June 24	July 8		12	5			
	July 9	July 22			3			
14	June 24	July 8		3	5			
	July 2	July 16			2	1		
	July 8	July 22			3	2		
15	June 23	July 8			4			
16	June 22	do			1	3		
17	July 5	July 22				9		
17–18	June 20–21	July 8			1	7		
18	June 23	July 11				3	15	
18–19	June 27–28	July 16				4	4	
	July 3–4	July 22				2	3	
19	June 22	July 11				3	12	
20	June 26	July 16				2	3	
	July 2	July 22					7	
22	June 24	July 16					4	1
23	June 23	do					6	2
24	June 22	do					6	4
24–25	June 27–28	July 22					2	1
25–26	June 20–21	July 16					7	10
26	June 26	July 22						4
27	June 25	do						6
29	June 23	do						6
31	June 22	July 23						4
32–33	June 20–21	do						4
38–39	do	July 29						2
40–41	June 18–19	do						1

In 1915 the earliest hatching took place on the seventh day after oviposition, the earliest first molt on the sixteenth day, the earliest second molt on the twenty-first day, the earliest third molt on the twenty-fifth day, and the earliest last molt on the twenty-ninth day, and the first larva to consume the entire seed contents had done so on the forty-ninth day. The last larva to finish feeding required 57 days.

Table II shows all the life-history data obtained during 1915 from cage-infested apples. As will be noted, all apples used in this work were infested during a period of 5 days from June 28 to July 2. Thus all individuals were developing under practically identical conditions. It will also be noted that many of the belated first-instar larvæ and eggs were found in the mucilaginous tissue surrounding the central gelatinous body.

TABLE II.—*Development of Syntomaspis druparum at North East, Pa., in 1915*

Period from oviposition to examination.	Date of oviposition.	Date of examination.	Stage and number of individuals found.						Remarks.
			Egg.	First larval.	Second larval.	Third larval.	Fourth larval.	Fifth larval.	
Days.									
6	June 29	July 5	10	.....	.....	.....	.....	.....	
7	June 28	...do.....	.....	3	.....	.....	.....	.....	
7	July 2	July 9	1	.....	.....	.....	.....	.....	
8	July 1	...do.....	6	6	.....	.....	.....	.....	
8	July 2	July 10	1	3	.....	.....	.....	.....	
9	June 28	July 7	1	5	.....	.....	.....	.....	
10	...do.....	July 8	.....	8	.....	.....	.....	.....	
11	...do.....	July 9	.....	7	.....	.....	.....	.....	
12	...do.....	July 10	.....	5	.....	.....	.....	.....	
12	July 2	July 14	.....	11	.....	.....	.....	.....	
13	June 28	July 11	.....	6	.....	.....	.....	.....	
13	July 1	July 14	.....	10	.....	.....	.....	.....	
14	June 28	July 12	.....	2	.....	.....	.....	.....	
15	...do.....	July 13	.....	25	.....	.....	.....	.....	
16	...do.....	July 14	.....	12	2	.....	.....	.....	
17	...do.....	July 15	.....	4	5	.....	.....	.....	
18	...do.....	July 16	.....	3	5	.....	.....	.....	
19	...do.....	July 17	1	6	10	.....	.....	.....	Egg and two first-stage larvæ were in mucilaginous tissue at large end of seed.
19	July 1	July 20	.....	2	3	.....	.....	.....	
20	June 28	July 18	.....	4	5	.....	.....	.....	
21	...do.....	July 19	.....	1	5	2	.....	.....	First-stage larva in mucilaginous tissue.
22	...do.....	July 20	1	1	5	2	.....	.....	Egg and first-stage larva in mucilaginous tissue, seeds considerably hardened.
22	June 29	July 21	.....	1	4	8	.....	.....	First-stage larvæ in mucilaginous tissue.
23	June 28	...do.....	.....	3	.....	6	.....	.....	Do.
24	...do.....	July 22	.....	.....	.....	2	.....	.....	
24	June 29	July 23	.....	.....	2	3	.....	.....	
25	June 28	...do.....	.....	.....	.....	7	2	.....	
26	...do.....	July 24	.....	.....	2	3	3	.....	
27	...do.....	July 25	.....	.....	1	1	6	.....	
28	...do.....	July 26	.....	.....	.....	.....	8	.....	
29	...do.....	July 27	.....	.....	.....	.....	6	.....	
29	July 2	July 31	.....	.....	.....	3	15	4	
30	June 28	July 28	.....	.....	.....	.....	4	.....	
30	July 1	July 31	.....	.....	.....	.....	7	1	
30	July 2	Aug. 1	.....	.....	.....	.....	4	4	
31	July 1	...do.....	.....	.....	.....	.....	8	7	
32	June 29	July 31	.....	1	.....	.....	6	8	First-stage larva in mucilaginous tissue.
32	July 2	Aug. 3	.....	.....	.....	.....	2	7	
33	July 1	...do.....	.....	.....	.....	.....	1	10	
33	July 2	Aug. 4	.....	.....	.....	.....	1	7	
34	July 1	...do.....	.....	.....	.....	.....	3	13	
35	...do.....	Aug. 5	.....	.....	.....	.....	1	13	
36	...do.....	Aug. 6	.....	.....	.....	.....	.....	8	
37	...do.....	Aug. 7	.....	.....	.....	.....	2	9	
38	July 2	Aug. 9	.....	.....	.....	.....	.....	13	
39	July 1	...do.....	.....	.....	.....	.....	1	8	
39	July 2	Aug. 10	.....	.....	.....	.....	3	20	
40	July 1	...do.....	.....	.....	.....	.....	.....	4	
40	July 2	Aug. 11	.....	.....	.....	.....	.....	17	
41	...do.....	Aug. 12	.....	.....	.....	.....	.....	12	
42	June 29	Aug. 10	.....	.....	.....	.....	.....	8	
43	June 28	...do.....	.....	.....	.....	.....	.....	2	
43	June 29	Aug. 11	.....	.....	.....	.....	.....	15	
44	...do.....	Aug. 12	.....	.....	.....	.....	.....	12	
45	...do.....	Aug. 13	.....	.....	.....	.....	1	10	
46	...do.....	Aug. 14	.....	.....	.....	.....	.....	8	
47	...do.....	Aug. 15	.....	.....	.....	.....	.....	11	
48	...do.....	Aug. 16	.....	.....	.....	.....	.....	7	
49	...do.....	Aug. 17	.....	.....	.....	.....	.....	9	2 had consumed entire seed contents.
50	July 2	Aug. 21	.....	.....	.....	.....	.....	9	
51	...do.....	Aug. 22	.....	.....	.....	.....	.....	7	3 had consumed entire seed contents.
52	...do.....	Aug. 23	.....	.....	.....	.....	.....	10	Do.
53	...do.....	Aug. 24	.....	.....	.....	.....	.....	8	4 had consumed entire seed contents.
54	...do.....	Aug. 25	.....	.....	.....	.....	.....	7	5 had consumed entire seed contents.
55	...do.....	Aug. 26	.....	.....	.....	.....	.....	7	Do.
56	...do.....	Aug. 27	.....	.....	.....	.....	.....	9	7 had consumed entire seed contents.
57	...do.....	Aug. 28	.....	.....	.....	.....	.....	7	Do.

On August 30, 1915, two days after the last cage-infested apple had been examined, 165 seeds infested naturally were examined to determine whether all larvæ had by that time finished feeding. Of the larvæ found, 132, or exactly 80 per cent, had consumed the entire contents of the seed and the rest had practically done so. Of 50 larvæ examined on September 2, all had finished feeding. In other words, by the last of August all the larvæ had reached full growth.

NUMBER MATURING IN A SINGLE SEED.—In removing larvæ from apple seeds the fact has been observed that as they increase in size and age the likelihood of finding more than one in a seed decreases. It is not at all uncommon to find 6 or 7 very young larvæ in a single seed, even in an apple naturally infested; but on only one occasion has more than 1 of the fifth instar been found within a single seed. In this case there were 2. The number is usually reduced to 1 before the fourth instar is reached. This reduction in number is brought about by the actual killing and eating of the surplus larvæ by the one which ultimately matures. On a number of occasions this cannibalistic habit has been observed, the larvæ concerned being usually in the second or third instar.

HIBERNATING LARVA.—When the larva has consumed its total supply of food it very shortly assumes what may be called the hibernating form (Pl. 38, D). This does not involve a molting of the skin but consists merely in longitudinal contraction of the body, the head and caudal segments being drawn in and the body becoming relatively thicker and more deeply wrinkled. In this condition it remains until the following spring.

BIENNIAL BROOD.—Not all of the larvæ from eggs of a given season finish their development and emerge as adults the following spring, but a large percentage of them remain as larvæ within the seeds until the second spring. This was suspected during the summer of 1914, when, on July 23, the writer, in examining some seeds infested in 1913, found some that still contained living larvæ. One hundred seeds were selected at random to determine roughly what percentage of the larvæ were likely to live over until the next spring. Of these 100 seeds, 54 contained dead larvæ, 26 living larvæ, and from 14 the adult insects had emerged. Of the living insects 65 per cent had not emerged. This lot of seed was kept until the summer of 1915 and count kept of the emerging adults. A total of 416 insects were reared in the second spring as against 339 in 1914. In other words, 55.1 per cent of the insects lived over two winters as larvæ.

It would appear that this curious habit serves to prevent extermination of the species by a season of no fruit.

PUPATION.—The larvæ begin to pupate during the latter half of May, the latest pupation, judging from the emergence of the adults, probably taking place from three weeks to a month later.

PUPA

DESCRIPTION.—The pupa (fig. 8) is normally, depending on the sex, from 3 to 4 mm. long, females being the larger. It is at first white, but later those parts that are chitinized in the adult become first brownish and later dark greenish; this color being really on the body of the adult, developing within the pupal skin and showing through the latter. The legs, wing pads, antennæ, and palpi are folded along the sides and venter, and in the female the ovipositor extends over the back, reaching nearly to the head.

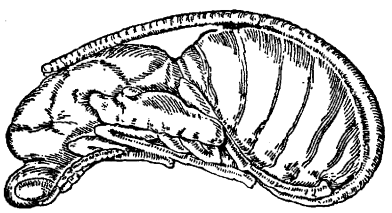

FIG. 8.—*Syntomaspis druparum:* Pupa of female. Much enlarged. (Original.)

PUPAL PERIOD.—The pupal period is of about four weeks' duration, some ndividuals requiring slightly less and some slightly more than this period.

ECONOMIC IMPORTANCE

As has been pointed out on an earlier page, the only commercial fruits that are, under conditions of ordinary care, at all heavily infested by the seed chalcid are the Lady apple and, occasionally, crab apples, both varieties with very limited markets. Also, under normal conditions of growth distortion of fruit to such extent as to render it unmarketable is rather rare, and infestation by the chalcid apparently has no effect on the color of fruit. As pointed out by Crosby and as proven by the observations of the writer, Lady apples are apparently practically immune to the distortion of oviposition. These things being true, it is apparent that economically the seed chalcid is of little importance.

CONTROL OF THE CHALCID

NATURAL CONTROL.—Apparently the apple-seed chalcid has no specific enemies. No records of such are to be found in European or American literature, and none has come under the observation of the writer. Other apple insects, such as the codling moth, which sometimes devour the seeds, undoubtedly destroy a limited number of chalcid larvæ, and others, which feed in the fallen apples, account for the death of a few more. Some adult chalcids doubtless fall prey to birds, spiders, and other predators. But all of these together constitute only a very small measure of control.

Mortality among the hibernating larvæ is apparently very small also; for of 115 larvæ found in apples that had lain under the tree all through the winter of 1914–15 only three were dead, and each of these was in a seed that had been eaten into by some other insect. The mortality in seeds that become separated from the pulp may be higher, but as it is almost impossible to find such seeds no data on the point are available.

ARTIFICIAL CONTROL.—Inasmuch as the seed chalcid attacks normally only varieties that are grown on a very small scale it can be controlled with comparatively little effort by purely mechanical means. In the first place, all wild seedling apples and wild crab apples in the neighborhood of such varieties should be destroyed. This would not only eliminate the outside source of this insect, but also of many other much more serious pests. This should be done in the spring or summer, preferably in August after oviposition has ceased, to insure the destruction of the chalcid larvæ of the season. From the seed crop of the previous season there will still be the chalcids of the biennial brood for the next following season to contend with, but in two years this source of infestation will be entirely eliminated. In addition to the foregoing the careful destruction of all drop fruit and culls for two seasons will practically exterminate the chalcids. If the waste fruit is converted into cider, the pomace should be destroyed.

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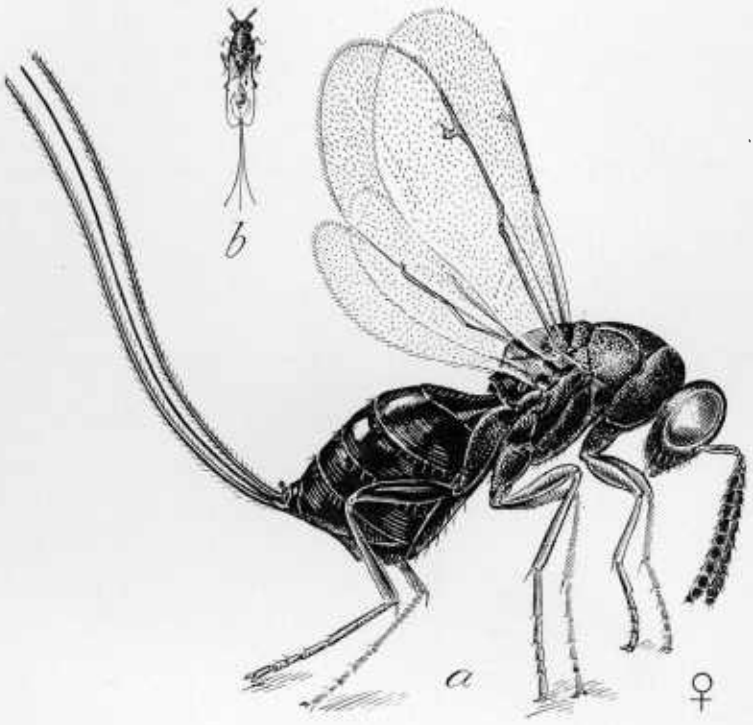
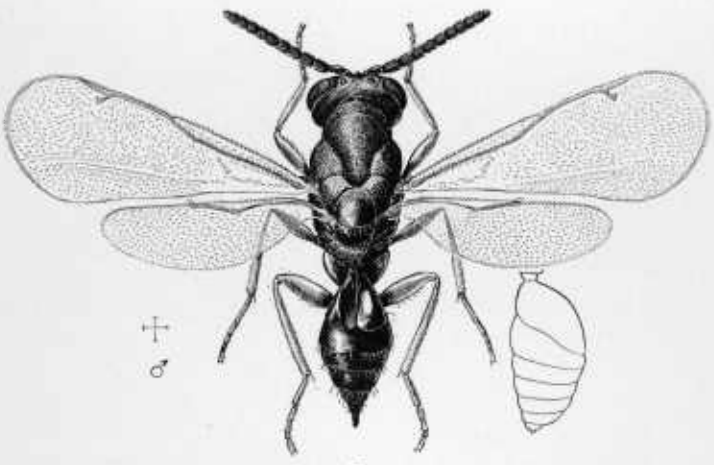
PLATE 37

Syntomaspis druparum:

A.—Adult female. *a*, greatly enlarged; *b*, × 3. (Original.)
B.—Adult male; outline of abdomen, lateral view, at right. Greatly enlarged. (Original.)



A



B

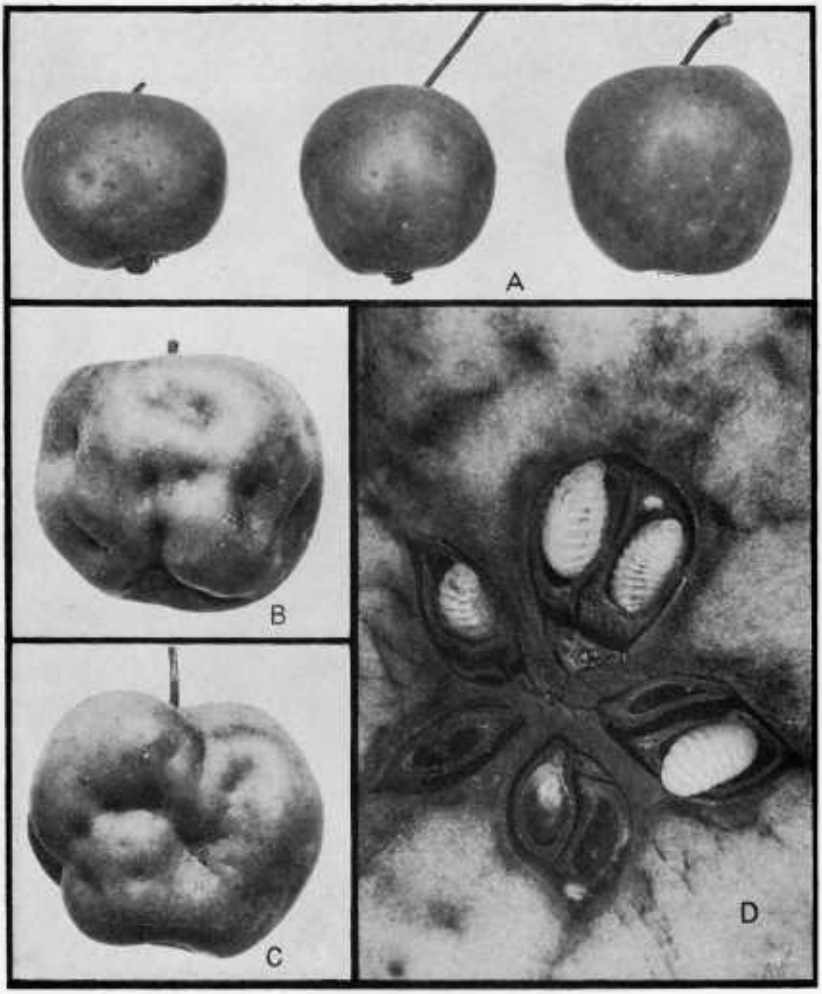

A
B
C
D

PLATE 38

Syntomaspis druparum: Apple injury and hibernating larvæ

A.—Usual type of injury resulting from oviposition. Natural size.
B, C.—Extreme type of injury resulting from oviposition. Natural size.
D.—Hibernating larvæ within seeds of an apple. Greatly enlarged.

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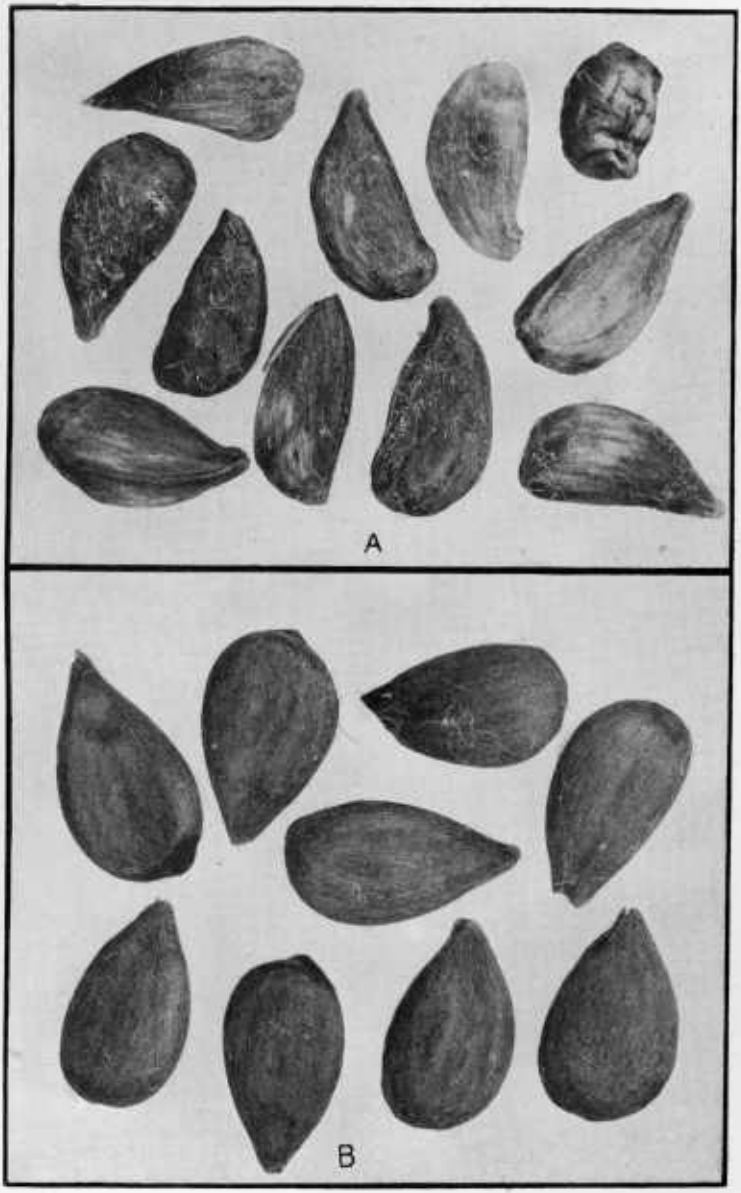
PLATE 39

Syntomaspis druparum: Infested and sound seeds of apples

A.—Infested seeds. Much enlarged.
B.—Sound seeds. Much enlarged.


A
B

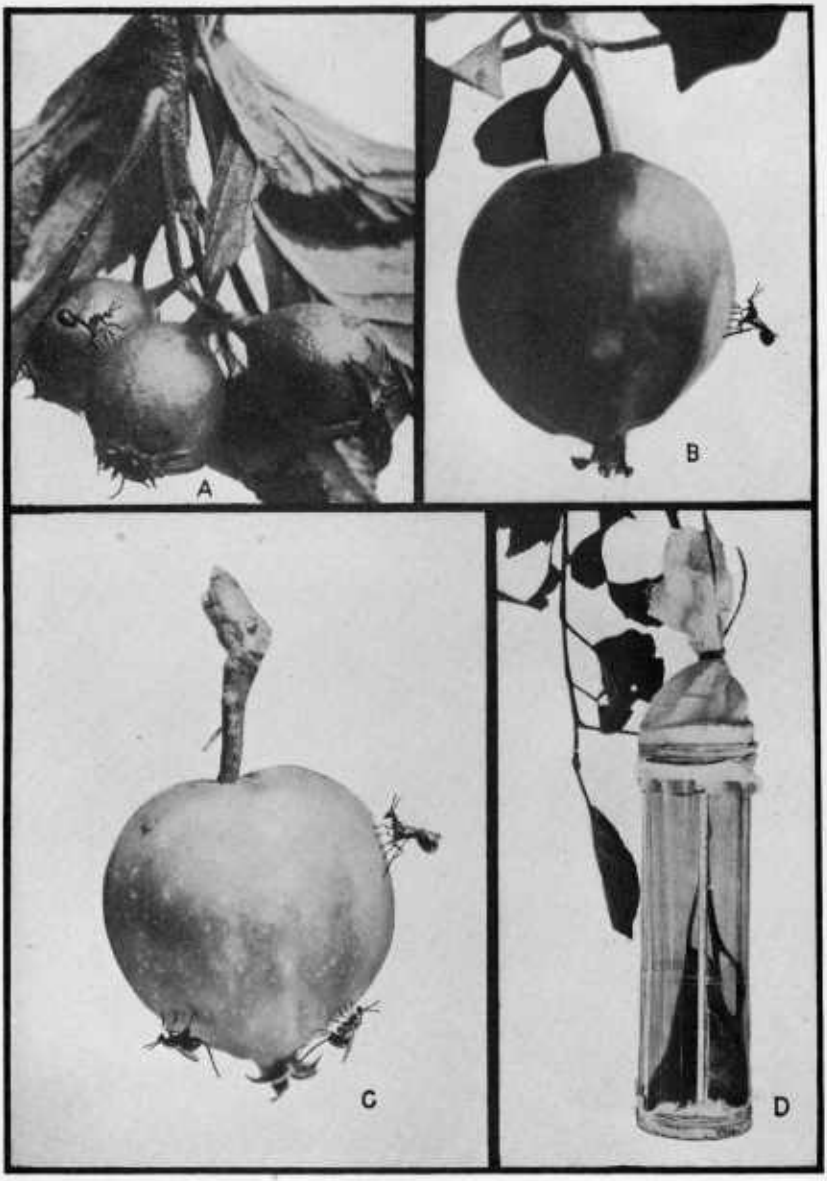

A
B
C
D

PLATE 40

Syntomaspis druparum: Oviposition

A.—Female ovipositing in fruit of *Crataegus* sp. Photographed from life. × 2.
B, C.—Oviposition in apples. Photographed from life. × 2.
D.—Mica cage used in the life-history studies of *Syntomaspis druparum*. × ⅓.